PERSPECTIVES FROM THE WEARABLE ELECTRONICS AND APPLICATIONS RESEARCH (WEAR) LAB, NASA JOHNSON SPACE CENTER

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As NASA moves beyond exploring low earth orbit and into deep space exploration, increased communication delays between astronauts and earth drive a need for crew to become more autonomous (earth-independent). Currently crew on board the International Space Station (ISS) have limited insight into specific vehicle system performance because of the dependency on monitoring and real-time communication with Mission Control. Wearable technology provides a method to bridge the gap between the human (astronaut) and the system (spacecraft) by providing mutual monitoring between the two. For example, vehicle or environmental information can be delivered to astronauts through on–body devices and in return wearables provide data to the spacecraft regarding crew health, location, etc.

The Wearable Electronics and Applications Research (WEAR) Lab at the NASA Johnson Space Center utilizes a collaborative approach between engineering and human factors to investigate the use of wearables for spaceflight. Zero and partial gravity environments present unique challenges to wearables that require collaborative, user-centered, and iterative approaches to the problems. Examples of the WEAR Lab's recent wearable projects for spaceflight will be discussed.

Perspectives From The Wearable Electronics and Applications Research (WEAR) Lab

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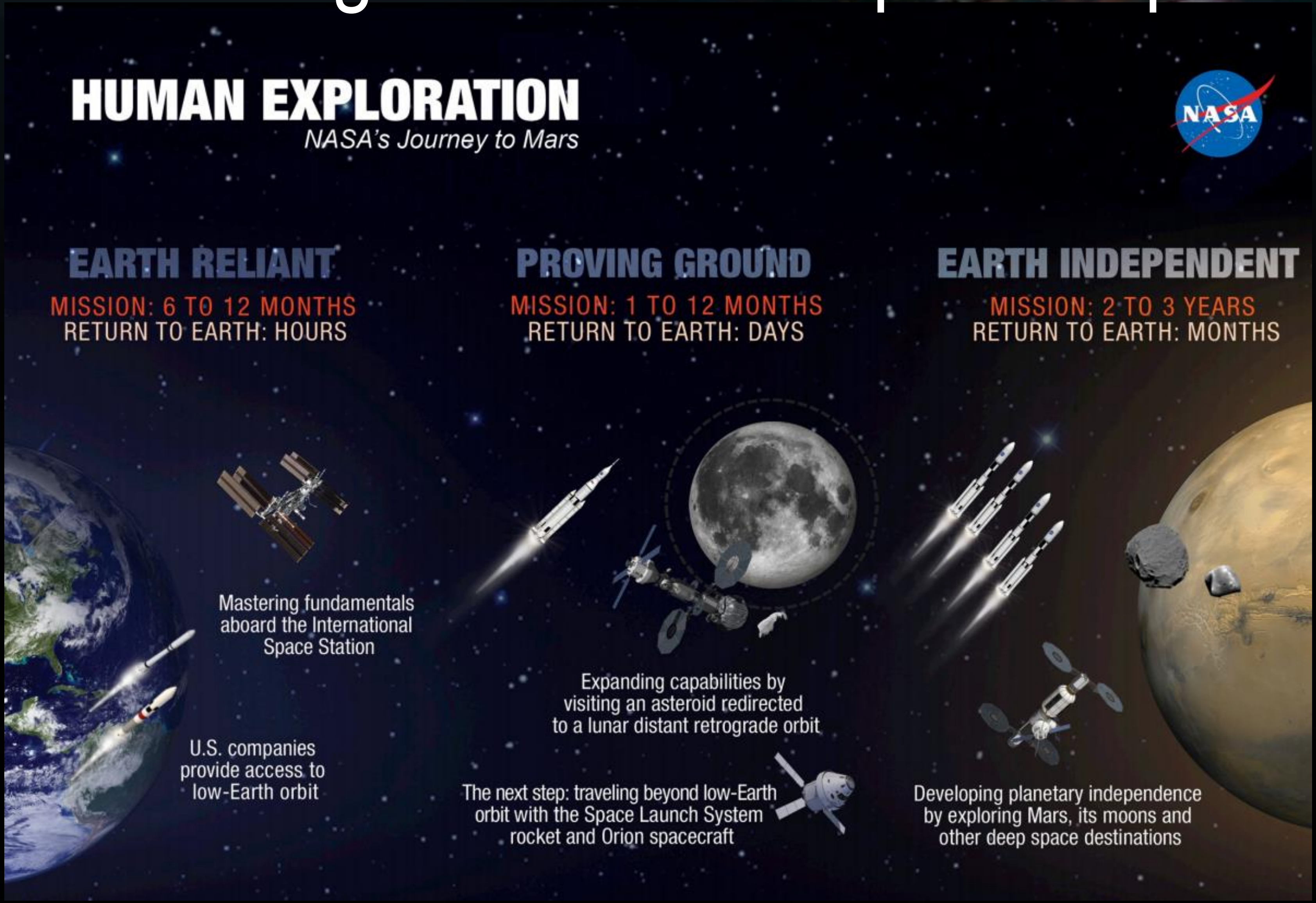
New Challenges of Human Space Exploration



Wearables & NASA

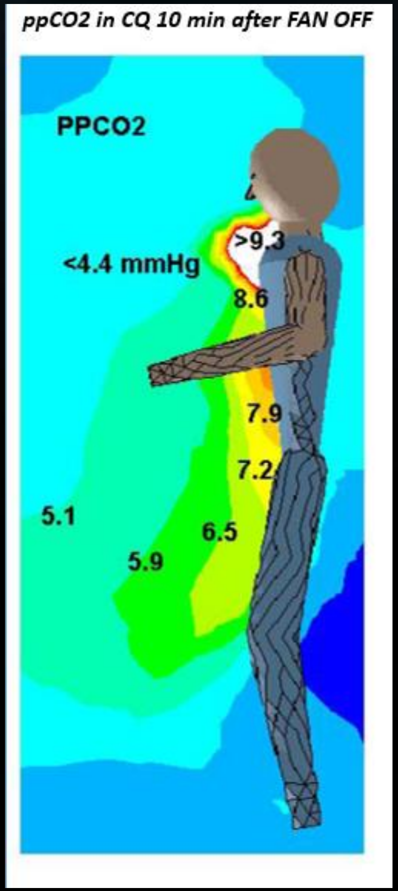
- Increased crew autonomy during long-duration (earth-independent) missions requires more vehicle insight for the crew
- Wearables provide a method to bridge the gap between the human (crew) and the system (spacecraft) by providing mutual monitoring between the two
- The Wearable Electronics and Applications Research (WEAR) Lab at the NASA Johnson Space Center is a collaboration between engineers and human factors to investigate the use of wearables for spaceflight

Environmental Monitoring Gap

- Numerous commercial (COTS) wearable devices meet NASA's need for human and environmental monitoring
- In zero gravity environments gasses behave differently than on Earth
    - Lack of natural convection limits air circulation and mixing potentially leading to "pockets" of hazardous gasses
- COTS wearables target gasses that pose hazards on earth (ex. carbon monoxide) leaving a monitoring gap for gasses whose hazards are mitigated with the help of gravity (ex. carbon dioxide)

Carbon Dioxide (CO_2) in Space

- Exposure to elevated CO_2 levels causes health problems
  - Increased blood pressure, dizziness, vision impairment, decreased decision-making capabilities, headaches, etc.
- Monitoring CO_2 in spacecraft is difficult
  - CO_2 readings from fixed sensors may not be representative of locations near the crew
  - Group activities (e.g. meals, public events) are of particular concern because of potential creations of "CO_2 Pockets"



Son, C., Zapata, J., and Lin, C., "Investigation of Airflow and Accumulation of Carbon Dioxide in the Service Module Crew Quarters," SAE Technical Paper 2002-01-2341, 2002, https://doi.org/10.4271/2002-01-2341.

Personal CO2 Monitor

- The WEAR Lab developed the Personal CO2 Monitor (PCO2M) to evaluate wearability principles in space and address the CO_2 monitoring need for the International Space Station (ISS)

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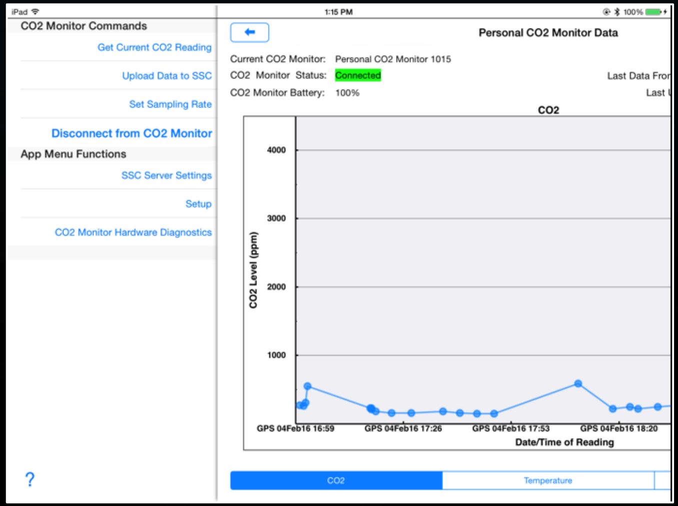
PCO2M System

Personal CO2 Monitors

- Monitors CO_2, relative humidity, and temp
- Clips onto crew clothing
- Simple LED status indicators
- Charges via USB
- Stores data internally, if no active Bluetooth connection is available

iPad app



- Downloads data from PCO2M via Bluetooth Low Energy
- Displays data real-time
- Aggregates & transfers data to ground server

Challenges & Lessons Learned

- No gravity - Things don't stay put
  - Affected attachment locations & methods as well as operations

- Conflicting priorities
  - Wearability & usability
    vs.
    Operations & science

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